GENERAL GROUNDWATER CONDITIONS
IN
MOUNTAIN AND MOUNTAIN VALLEY AREAS
OF
SANTA CLARA COUNTY

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INTRODUCTION

Approximately one-third of Santa Clara County is underlain by large, relatively flat alluviated valleys, and two-thirds by mountainous areas. A very large percentage of the populace of the County inhabits the valley floor areas where virtually all the cultural development has occurred, while the mountainous areas are sparsely inhabited or completely undeveloped. With the continuing growth of the County and changes of life styles, there appears to be greater mounting pressures to develop in certain portions of the mountainous areas. Any development in mountainous areas would have to contend with greater potential problems due to the area's more severe topography and greater variability of physiographic and geologic conditions. Considerations that would have to be addressed either on an individual and/or cumulative bases include suitability of the building site, water supply, water quality, liquid waste disposal and its potential effect upon water quality, watershed protection, protection from fire, and access.

This report will only discuss, in a general manner, groundwater as a source of water, its quality, and possible problems relating to it that might occur as a result of future mountain suburban development. This presentation is based upon the expected water-bearing properties of the various formations and the modes of occurrence, recharge, and movement of groundwater.

No field work has been performed, so this discussion is largely based upon empirical relationships noted in similar areas and upon the meager groundwater data on file. This discussion is provided to serve as input to possible future mountain development planning policies and as a basis for performing a detailed study on groundwater conditions for specific site areas.

GENERAL GROUNDWATER CONDITIONS

Within the mountainous areas it can be concluded that groundwater supplies are meager and yields to wells, though variable, are usually small. However meager these supplies are, they represent the only water supply available at this time to individual domestic dwellings that sparsely populate the mountainous areas. At present the quality of groundwater is considered to be adequate for most uses.

One of the major potential problems related to groundwater in mountainous areas is protection of quality of existing groundwater supply with imminent increased suburban development, particularly if such growth relies on individual septic tanks for liquid waste disposal. This factor is, perhaps, possibly more of a limiting factor to development in mountainous areas than is water quantity.

GROUNDWATER SUPPLY

Water-bearing and Non-water-bearing Formations

For groundwater study purposes, the geologic formations are grouped into either water-bearing or non-water-bearing formations. The basis for the division is the ability of individual formation to yield water to wells. Water-bearing formations are those that readily absorb, transmit, and yield a copious quantity of water to wells for a sustained period; whereas, formations classed as non-water-bearing are those that yield a relatively limited quantity of water to wells, and sometimes fail entirely during "dry" periods.

Water-bearing formations are unconsolidated valley fill alluvium, old alluvium, and the Santa Clara Formation, all of which comprise the major groundwater basins of Santa Clara County.

Non-water-bearing formations are the consolidated bedrock units which underlie most of the mountain areas of the County. Bedrock formations contain and transmit water through fracture openings in the rock, which, collectively, contain only meager amounts of water as compared to sand and gravel aquifers of the groundwater basin. The ability of a well to obtain water from bedrock depends upon the number of open fractures the well encounters. Hence, the yield from one well to another may be quite variable but, generally, is expected to be small. Yield may vary from less than one gallon per minute to ten gallons per minute on a sustained basis, but would average toward the lower portion of this range.

A relatively small portion of the mountainous areas is underlain by water-bearing formations. These formations include the

Santa Clara Formation which occurs along portions of the foothills adjacent to the major valley areas, and stream-deposited alluviums which occur in the mountain valleys. The Santa Clara Formation in the foothills generally also has low yields due to its inherent low permeability. The stream-deposited alluviums are generally shallow and groundwater availability in these deposits is dependent upon the existence of surface streamflow and the recharge from the underlying bedrock (which must be fractured along the proper gradient).

Occurrence, Recharges, and Movement of Groundwater

Bedrock Formations

Groundwater in bedrock occurs in open fractures with perhaps only a small amount in interstitial opening in the weathered rock zone and residual soil zone. Most rocks in the area have been considerably disturbed by earth movements and thus contain water-bearing openings. The depth below the surface to which fractures may be open is limited by the ability of the rock to hold the fractures open under the weight of the overlying rock and soil mass; consequently the frequency of occurrence and the openess of the fractures diminish with depth.

Groundwater in fracture openings can occur under unconfined (water table) conditions or confined (under pressure) conditions. The confining pressure is caused by water below the water table moving down along an inclined open fracture with the upper rock block acting as a confining body. Individual confined conditions are limited to small areas. However, for the purpose of groundwater studies in mountainous bedrock terrane, the water body may be considered as that of a water table condition.

Groundwater in the fracture zone is derived from precipitation within the area where portions of the precipitation may run off directly with the remaining portion seeping into the ground, being transpired by plants or evaporating. Where bedrock is exposed or is at a shallow depth below the soil cover, generally in areas of steeper slopes and limited vegetative cover, direct runoff is usually rapid and recharge is a much smaller portion of the total than in areas of lower relief and deeper soil cover which has a greater capacity to absorb and retain water. The residual soil cover and the weathered rock zone serve as a "sponge" and temporary reservoir which absorbs rainfall and delivers that amount in excess of evapotranspiration to the underlying fracture systems. Where soil is absent, precipitation would directly enter the fractures. Thereafter, acting under the force of gravity, water moves along open fractures to the groundwater table.

Groundwater movement in rock fractures is influenced by the openess and the interconnectiveness of the fractures. Fracture openings either may be interconnected over a widespread area or may be a single fracture of group of fractures not connected with adjacent water bodies. If the openings are interconnectedd, a common water table results; if openings are isolated, each has an individual water table. The water table slope in mountainous areas generally varies with the relief of the land surface and, hence, has greater relief than in the flatter valley areas underlain by pervious alluvial material of the major groundwater basins. Where the fractures are interconnected, groundwater would flow down the gradient along the fracture plane openings. Topography exercises a strong influence on the water table slope since it controls the escape of effluent seepage (diffused discharge into streams). Streamflows of the mountainous areas are sustained by effluent groundwater seepage after seasonal precipitation and direct runoff have ceased. At this time a large portion of the recharged water flows downslope and then eventually discharges unused into the stream courses, since groundwater is essentially undeveloped in the mountainous area (except in small local areas).

Santa Clara Formation

The Santa Clara Formation is a bedded alluvial unit which is generally more compacted than the young alluvial deposits of the major groundwater basins. These bedded deposits are lightly folded in the foothills adjacent to the floor of the major valley areas and they then gently dip beneath the young alluvial deposit of the valleys. Due to their higher percentage of fine grain materials (clay and silt) and the higher degree of compaction, these deposits have a much lower permeability than the young alluvial deposits which comprise the major groundwater basins.

Groundwater occurs within the Santa Clara Formation as "unconfined" and "confined" with confining layers being silt beds of low permeability. Recharge is principally from streams and direct precipitation with some occurring as subsurface flow from the bedrock. With the higher permeability zones occurring along the bedding plane rather than across it, precipitation occurring on the uptilted edges of the bedding would favor a flow downward along the bedding planes. In this manner, this formation in part recharges groundwater to the alluvial deposits in the valley areas.

Mountain Valley Alluvium

Stream-deposited alluviums in mountain valleys are usually shallow and groundwater occurring in these units is unconfined. Recharge is from streamflow, direct precipitation, and subsurface flow from the underlying bedrock. Movement of groundwater is from the elevated edges of the valley and upstream end of the valley toward the central and lower end of the valley with slight modifications if groundwater pumping is occurring. Unsually the groundwater is discharged from the alluvium at the downstream end of the valley back into the stream.

Groundwater Storage and Development Potential

Although the storage capacity and development potential of groundwater in bedrock are far less than within the groundwater basins, it is possible to obtain yields from wells which could adequately supply an individual domestic dwelling provided that a well site is carefully selected. Because the performance of an individual well depends upon the number of water-bearing fractures intersected, one well may provide an adequate quantity of water whereas a nearby well may yield an insufficient quantity if only a few water-bearing fractures are encountered. Water levels may also be at different levels within closely spaced wells.

Owing to the meager storage capacity of the fracture openings that occurs within bedrock, there is a lack of holdover storage from the previous year's precipitation within the individual drainage areas; hence, any one year of subnormal rainfall may cause some shallow wells to go dry. Two or more subnormal precipitation years in succession may cause many shallow wells to go dry. Flows in springs along the streams may also cease or be greatly reduced. A subsequent normal precipitation year may restore groundwater to its original level.

Currently, only a small percentage of the potentially available water is being pumped from the bedrock formations. Despite this, the water in storage is subject to a wide range of seasonal fluctations due to the limited storage capacity of the fractured bedrock and to the groundwater flowing downslope and eventually discharging unused into the streams.

It is also noted that open fracture zones may not be continuous laterally and diminish with depth below ground surface. Hence, each individual drainage area within a drainage basin represents an individual subbasin with the bedrock drainage divide serving as an impermeable barrier. Groundwater recharge to each subbasin is thereby dependent upon that precipitation which falls within the individual subarea. Consequently, a large collective yield of groundwater through the construction of numerous wells usually cannot be achieved within a local area; in fact, the drilling of additional wells may deplete the supply in nearby existing wells.

Another limiting factor of groundwater development in bedrock where unsewered development area occurs is the maintenance of water quality. This will be discussed under "Water Quality".

Within the Santa Clara Formation the storage capacity is suspected to be adequate to sustain a suburban-type development. However, the permeabilities which govern the yield to wells are suspected to be variable but usually low. Test well drilling will be required to determine if large capacity municipal wells could be constructed within the Santa Clara Formation.

Although permeability of the stream-deposited alluviums in the mountain valleys may be high, the storage capacity is small due to the limited areal extent and depth of the deposits. Sustained yields from this type of unit are largely dependent upon recharge from streamflows and subsurface flows from the underlying formations. Groundwater pumped from the alluvium would easily be subject to pollution from surface sources due to the shallow depth of the overlying cover.

Selection of Well Sites

Within the mountainous bedrock areas, gullies, stream valleys, and low, broad valley areas are most favorable for constructing a successful well. These areas are usually where bedrock is most intensely fractured and to where groundwater migrates (moving downslope).

Areas of low relief on the hillsides are also favorable well site areas within bedrock terrane. These low-relief areas are mantled by soil cover and a deeply-weathered bedrock zone which are favorable recharge units. Also, since surface water and groundwater moves downslope toward these areas from the upper slopes, the water levels tend to be at shallower depths and do not fluctuate as widely as do those levels located atop a hill or ridge. In bedrock terrane the hilltops and ridges indicate areas of resistant rock where the frequency of structural rock openings can be expected to be less than in the gullies and valleys.

Within the Santa Clara Formation the same principal can be applied in the selection of a well site but, additionally, synclinal areas (downwarped bedding structure) may be favorable since the higher permeability of the formation favors the bedding plane.

Within the stream-deposited valley alluvium, the most favorable sites would be where its thickness is the greatest, generally within the interior portion of the valley.

Well Standards

Any wells to be drilled within Santa Clara County would have to be constructed in conformance with Ordinance No. 75-6 "An Ordinance of Santa Clara Valley Water District Regulating the Classification, Construction and Sealing of Wells". Additionally, certain other regulations of the County Health Department would have to be incorporated. The purposes of these regulations are to protect quality of the water supply for present and future uses.

WATER QUALITY

The quality of groundwater occurring within the mountainous areas of the County is not monitored as in the major groundwater basins. Consequently, filed data regarding groundwater quality are virtually nonexistent. It can be surmized that the quality of groundwater in mountainous areas is a reflection of surface water quality, but with a slightly higher dissolved mineral content. Analyses of surface waters indicate their quality to be excellent for most beneficial uses. Groundwaters are expected to be of acceptable quality, possibly with some exceptions. However, it is suspected that the bedrock groundwater could be increasingly salty with depth due to the possible occurrences of connate waters entrapped in some of the marine-deposited formations.

Although filed data on actual or potential groundwater quality problems (or nuisances) are lacking, possible high iron content and turbidity in isolated instances may become apparent within the bedrock areas if a survey is made. The turbidity could be caused by an occasional loosening of clay seams that fill some fractures. In other areas, reports of turbidity were noted shortly after rain storms which indicated that surface waters were entering wells through improper well construction, or through open fractures without undergoing natural filtration.

One of the major potential problems related to groundwater in mountainous areas is that of water quality protection if the environment becomes stressed by changing to a more intensive land use. Groundwater in bedrock is particularly susceptible to pollution from surface sources because the water table is generally at a shallow depth and influent seepage (recharge) to the groundwater table can occur unfiltered through open fractures. Even a small amount of pollutants entering the groundwater may exert a significant influence because water stored in open fractures is relatively small.

If suburban growth relying on individual septic tanks occurs in the mountainous area, an increase in nitrates and chlorides could be expected in the groundwater. Coliform bacteria would be filtered out if the leachfields were constructed in soils; if they are constructed in weathered bedrock, some of the sewage effluent may directly recharge the groundwater body through supercapillary fractures without undergoing filtration. Within a local area, inclined open fractures or interconnected fractures systems can transmit sewage effluent directly from the leach lines to the lower uncased or perforated portion of a well, even though great care is exercised in providing for a sanitary seal in the upper portion of the well. Where the terrain is steep and soil cover is thin, sewage effluent may flow to the surface through open fractures and thereby create a health hazard or nuisance condition.

If the mountainous areas become highly developed without the installation of a municipal-type sewer system, contamination problems may become apparent within the development and in the areas downslope; the valley trough areas probably would be most susceptible to quality degradation by contaminants. Also, within the mountain valley areas where water levels are usually at a shallow depth, sewage disposal by septic tanks would become a serious problem; infiltration from leach lines would not only contaminate the shallow groundwater, but would also build up a groundwater mound rising to the surface and causing additional disposal and sanitation problems.

Since streamflows in mountainous areas are sustained by effluent groundwater seepage (groundwater discharge) during the summer and fall months, contaminated groundwater would then also become a surface water problem which could affect areas far beyond the development site. Providing for an adequate sewage disposal system for any type of development within a mountainous area should be a paramount consideration.

RECOMMENDATIONS

Groundwater conditions in the mountainous areas are sensitive to stresses applied by a more intensive land use and any contemplated changes in land use would have to be carefully studied, particularly in regard to groundwater supply and protection of its quality.

In order to assess the groundwater supply for any extensive low density or moderately-sized high density development for a particular area, test drilling programs may be required to determine the adequacy of supply. In the protection of quality, water disposal systems would have to be evaluated. Septic tank sites would have to be carefully evaluated for suitability of site location. This would entail the evaluation of the presence of soil, its percolation characteristics, its depth and areal extent to determine capacity, the septic tank site in relation to topography and well location, and the depth to water table. If contaminants or pollutants find their way to the groundwater supply, the water supply would have to be chlorinated before household use.

For a proposed development project, a surveillance or monitoring program may be required to measure any changing effects upon surface water and groundwater quality. Analyses of surface water and groundwater should determine not only their mineral quality character, but also their pollutional indicators, whether they be mineralogical, chemical, or biological. It is important to recognize any adverse effects as early as possible before they become permanent or irreversible so that corrective measures can be implemented.

DEFINITION OF SELECTED TERMS

(Reference: Largely from C. F. Tolman, 1937, Groundwater, McGraw-Hill Book Co., Inc., New York and London).

Water Table. In pervious granular material the water table is the upper surface of a body of free water which completely fills all openings in material sufficiently pervious to permit percolation. In fractured impervious rocks and in solution openings, it is the surface at the contact between the water body in the openings and the overlying ground air.

Unconfined Groundwater. Groundwater that occurs under water table conditions.

Confined Groundwater. A body of groundwater overlain by material sufficiently impervious to sever free hydraulic connection with overlying groundwater except at the intake. Confined water moves as in a conduit under pressure due to difference in head between intake and discharge areas of the confined water body.

Piezometric Level on Pressure Surface. The surface to which confined water will rise in nonpumping wells which pierce a common conduit and the water levels of which are not affected by a pumping well. It is a graphic representation of the pressure exerted by confined water on the conduit walls.

Artesian Well. A well tapping a confined or artesian aquifer in which the static water level stands above the water table. The term is sometimes used to include all wells tapping confined water, in which case those wells with water levels above the water table are said to have positive artesian head (pressure) and those with levels below the water table, negative artesian head. A flowing artesian well is an artesian well where the pressure surface is above the land surface.

Perched Groundwater. Groundwater occurring in a saturated zone separated from the main body of groundwater by unsaturated rock (or soil).

Semiperched Groundwater. Shallow groundwater overlying a body of groundwater from which it is not separated by any unsaturated alluvium (perched groundwater but not separated by an unsaturated zone from the main groundwater body; separation is achieved by the nearly impermeable nature of the perching clay layer and if the main groundwater body were drawn down, a true perching condition would result).

Temporarily Perched Groundwater. A perched groundwater condition that occurs on a temporary basis. This may be caused by the perching layer being semipermeable or by waters slowly and eventually flowing off the perching layer on its journey to the main groundwater body.

Effluent Seepage. Diffuse discharge of groundwater to the ground surface; e.g., effluent stream condition is where streamflow is sustained, wholly or in part, by diffused groundwater discharge from the soil or rock.

Influent Seepage. Movement of water downward in the zone of aeration from the ground surface toward the water table; e.g., influent stream condition is where streamflow losses occur as water seeps into the ground.